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Data Summary Report: Comparative Exposure Study Libby Asbestos Superfund Site, Operable Unit 4

Revision 0 – July 2013

Work Assignment No.: **329-RICO-08BC**
Libby Asbestos Superfund Site, OU4
Remedial Investigation/Feasibility Study

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ACRONYMS AND ABBREVIATIONS

ABS	activity-based sampling
cc	cubic centimeters
CDM Smith	CDM Federal Programs Corporation
cm	centimeter
DQA	Data Quality Assessment
DQO	data quality objectives
EDD	electronic data deliverable
EDS	energy dispersive spectroscopy
EPA	U.S. Environmental Protection Agency
ESAT	Environmental Services Assistance Team
FBAS	Fluidized bed asbestos segregator
FSDS	Field Sample Data Sheet
ft^2	square feet
g	gram
GO	Grid Opening
HV	High Volume
ID	identification
L	liters
L/min	liters per minute
LA	Libby amphibole
LFO	Libby Field Office
LV	Low Volume
mL	milliliter
mm	millimeter
Ms/cm^2	million structures per square centimeter
Ms/g	million structures per gram
PCM	phase contrast microscopy
PCME	phase contrast microscopy equivalent
QA/QC	quality assurance/quality control
QAPP	quality assurance project plan
QATS	Quality Assurance Technical Support
QC	quality control
s/cc	structures per cubic centimeter
s/cm^2	structures per square centimeter
s/g	structures per gram
SAED	selected area electron diffraction
SAP	sampling and analysis plan
SPF	Soil Preparation Facility
SOP	standard operating procedure
TEM	transmission electron microscopy
VWC	volumetric water content

EXECUTIVE SUMMARY

Introduction

Libby is a community in northwestern Montana that is located near a large open-pit vermiculite mine. Vermiculite from this mine contains varying levels of a form of asbestos referred to as Libby amphibole (LA). Starting in 2000, the U.S. Environmental Protection Agency (EPA) began taking a range of cleanup actions at the Libby Asbestos Superfund Site (Site) to reduce or eliminate sources of LA exposure to residents and workers.

In order to put residual levels of exposure and risk that may exist for Libby in perspective, EPA conducted a Comparative Exposure Investigation designed to collect data on outdoor exposures for people living or working in nearby cities that are not impacted by the mine. A brief description of this investigation and its findings is summarized below.

Comparative Exposure Investigation Description

The EPA has performed several investigations at the Site to evaluate potential exposures to LA released from source materials by measuring the concentration of LA in breathing zone air during various disturbance activities, referred to as "activity-based sampling" (ABS). As part of these ABS studies, LA has been measured in outdoor ABS air, soil, tree bark, and duff material. The Comparative Exposure Investigation was designed to collect data on LA concentrations in the same media from cities near the Site that are not affected by the mine which can provide a frame of reference for comparisons to exposures in Libby. Three nearby cities – Eureka, Helena, and Whitefish – were selected to provide reference data for a range of locations. In the past, Eureka and Helena have been sampled as part of the Site ambient air monitoring program. Eureka and Whitefish are in the predominant downwind direction (northeast) of the vermiculite mine. In addition to these reference areas, a location south of Libby, in a timber sale area, was also evaluated to provide data from within the Libby Valley.

Because the levels of LA in outdoor ABS air generated during soil disturbance scenarios may depend on factors that vary seasonally (e.g., soil moisture, wind speed, humidity), the Comparative Exposure Investigation was conducted in August when rainfall and soil moisture levels were expected to be at or near their lowest for sampling. ABS air, soil, tree bark, and duff samples were collected from three different areas at each city and one area at Flower Creek. LA levels in outdoor ABS air were sampled during two different types of simulated soil disturbance activities – a child digging in soil and a firefighter digging a fire line.

Major Findings

- Low levels of LA were observed in soils from outside of the Libby Valley (i.e., Eureka, Helena, Whitefish). For these soil samples, the LA structures observed were ranked as being characteristic of actinolite or tremolite and no sodium or potassium was noted in the spectra for these structures. This would indicate that these structures do not likely originate from the vermiculite ore deposit at the Libby mine site (Meeker *et al.* 2003).

- LA was also observed in soils from Flower Creek within the Libby Valley. Nearly all of the LA structures observed were characterized as being part of the solid solution series of winchite, richterite, tremolite, and actinolite, and had spectra that showed they contained sodium and potassium, which is supportive of the conclusion that they are derived from the Libby vermiculite ore deposit (Meeker *et al.* 2003).

- Phase contrast microscopy-equivalent (PCME) LA structures were not detected in any of the ABS air samples from Helena, Whitefish, Eureka, or Flower Creek. These results demonstrate that, despite the fact that detectable levels of asbestos were noted in the soils, active disturbances of these soils did not result in detectable releases of PCME LA to air.

- LA structures were not detected in duff or tree bark samples outside of the Libby Valley (i.e., Eureka, Helena, Whitefish). However, low levels of LA were detected in tree bark and duff samples from Flower Creek within the Libby Valley. Similar to the soils from Flower Creek, the LA structures were characterized as being part of the solid solution series of winchite, richterite, tremolite, and actinolite, and had spectra that showed they contained sodium and potassium, which is supportive of the conclusion that they are derived from the Libby vermiculite ore deposit (Meeker *et al.* 2003).

1 Introduction

1.1 Site Background

Libby is a community in northwestern Montana located 7 miles southwest of a large open-pit vermiculite mine that operated from the 1920s until 1990. The mine began limited operations in the 1920s and was operated on a larger scale by the W.R. Grace Company from approximately 1963 to 1990. Studies have shown that vermiculite from this mine contains varying levels of a form of asbestos referred to as Libby amphibole (LA). Historic mining, milling, and processing operations at the mine, as well as bulk transfer of mining-related materials, tailings, and waste to locations throughout Libby Valley, are known to have resulted in releases of vermiculite and LA to the environment that have caused a range of adverse health effects in exposed people. Epidemiological studies revealed that workers at the mine had an increased risk of developing asbestos-related lung disease (McDonald *et al.* 1986, 2004; Amandus and Wheeler 1987; Amandus *et al.* 1987; Sullivan 2007; Larson *et al.* 2010, 2012a, 2012b). Additionally, radiographic abnormalities were observed in 17.8 percent (%) of the general population of Libby including former workers, family members of workers, and individuals with no specific pathway of exposure (Peipins *et al.* 2003).

Although the mine has ceased operations, historic or continuing releases of LA from mine-related materials could be a source of ongoing exposure and risk to current and future residents and workers in the area. Starting in 2000, the U.S. Environmental Protection Agency (EPA) began taking a range of cleanup actions in Libby to reduce or eliminate sources of LA exposure to residents and workers. The Libby Asbestos Superfund Site (Site) was listed on the National Priorities List in October 2002.

1.2 Purpose of this Document

Multiple investigations conducted at the Site have demonstrated that LA is present in environmental source media (e.g., soil, tree bark, duff material[1]) at locations in and around the Site. As a result, individuals may be exposed to LA that is released to air during source disturbance activities. These inhalation exposures may pose a risk of cancer and/or non-cancer effects. The EPA has also performed several investigations at the Site to evaluate potential exposures to LA released from source materials by measuring the concentration of LA in breathing zone air during various disturbance activities, referred to as "activity-based sampling" (ABS). As part of these ABS studies, concentrations of LA have been measured in outdoor ABS air for the purposes of evaluating potential inhalation exposures.

In 2012, EPA performed an investigation, referred to as the Comparative Exposure Investigation, to collect data on LA concentrations in outdoor ABS air, soil, tree bark, and duff material from cities near the Site that are not expected to be affected by the mine to provide a

[1] Duff material consists of leaf litter, pine needles, and organic debris on the ground surface.

frame of reference for comparisons to exposures in Libby. Three nearby cities were selected for evaluation: Eureka, Helena, and Whitefish. In addition to these reference areas, a location near Flower Creek in a timber sale area south of Libby was also evaluated as part of this investigation to provide data from within the Libby Valley.

This document presents results for data collected during the Comparative Exposure Investigation.

1.3 Document Organization

In addition to this introduction, this report is organized into the following sections:

Section 2 This section summarizes data management procedures, including sample collection, documentation, handling, custody, and data management.

Section 3 This section summarizes the design of Comparative Exposure Investigation, and describes the data that were collected in this investigation, the analytical methods used for estimating the level of LA in air, tree bark, duff, and soil, as well as the data reduction methods utilized in this report.

Section 4 This section summarizes the results for data that were collected for the Comparative Exposure Investigation, including an evaluation of the levels of LA in each source media from each sampling location.

Section 5 This section presents the results of the data quality assessment, including a summary of program audits, modifications, data verification efforts, an evaluation of quality control samples, and a data adequacy assessment.

Section 6 This section provides full citations for all analytical methods, site-related documents, and scientific publications referenced in this document.

All referenced tables and figures are provided at the end of this document. All referenced appendices are provided electronically.

2 Data Management

2.1 *Sample Collection, Documentation, Handling, and Custody*

All outdoor ABS air, soil, tree bark, and duff samples generated as part of the Comparative Exposure Investigation were collected, documented, and handled in accordance with standard operating procedures (SOPs), as specified in the *Sampling and Analysis Plan/Quality Assurance Project Plan (SAP/QAPP): Comparative Exposure – Eureka, Helena, Whitefish, Libby Asbestos Site, Operable Unit 4* (EPA 2012a), and in the SAP/QAPP Addendum (EPA 2012b) to add the Flower Creek sampling location. These documents were prepared to guide sampling efforts conducted in Eureka, Helena, Whitefish, and Flower Creek, Montana. Detailed information on sample collection methods for each medium collected as part of this investigation is provided in Section 3.

All samples (i.e., ABS air, soil, tree bark, and duff) collected in the Comparative Exposure Investigation were identified with sample identification numbers (IDs) that include a program-specific prefix of "CX" (e.g. CX-00001). Data on the sample type, location, collection method, and collection date of all samples were recorded both in a field log book maintained by the field sampling team and on a field sample data sheet (FSDS) designed to facilitate data entry into the field Scribe project database (see below). All samples collected in the field were maintained under chain of custody during sample handling, preparation, shipment, and analysis.

2.2 *Analytical Results Recording*

Standardized data entry spreadsheets (electronic data deliverables, or EDDs) have been developed specifically for the Libby project to ensure consistency between laboratories in the presentation and submittal of analytical data. In general, a unique Libby-specific EDD has been developed for each type of analytical method and medium. Each EDD provides the analyst with a standardized laboratory bench sheet and accompanying data entry form for recording analytical data. The data entry forms contain a variety of built-in quality control functions that improve the accuracy of data entry and help maintain data integrity. These spreadsheets also perform automatic computations of analytical input parameters (e.g., analytical sensitivity, dilution factors, and concentration), thus reducing the likelihood of analyst calculation errors. The EDDs generated by the laboratories are uploaded directly into the analytical Scribe project databases (see below).

2.3 *Hard Copy Data Management*

Hard copies of all FSDSs, field log books, and chain of custody forms generated during the Comparative Exposure Investigation are stored in the CDM Smith field office in Libby, Montana. **Appendix A.1** of this report provides copies of all the FSDS and chain of custody forms for samples collected as part of the Comparative Exposure Investigation.

Hard copies of all analytical bench sheets are included in the analytical laboratory reports. These analytical laboratory reports are submitted to the Libby Laboratory Coordinator. **Appendix A.2** of this report provides copies of all the analytical laboratory reports for analyses performed as part of the Comparative Exposure Investigation.

2.4 *Electronic Data Management*

Sample and analytical electronic data are stored and maintained in the Libby Scribe project databases that are housed on a local computer located at the TechLaw office in Golden, Colorado, which is backed up daily to an external hard drive.

Raw data summarized in this report were downloaded from Scribe.NET on 7/24/2013, into a Microsoft Access® database by CDM Smith. Any changes made to these Scribe projects since this download will not be reflected in the Access database. Because data for the Libby project are maintained in multiple Scribe projects (e.g., analytical data are managed in annual projects, field information is managed in a project separate from the analytical information), the data have been combined into one Access database reflecting a compilation of tables from multiple Scribe projects. A copy of this Access database is provided in **Appendix B** of this report.

3 Comparative Exposure Investigation Design

3.1 *Study Design*

Detailed information on the Comparative Exposure Investigation design and program-specific data quality objectives (DQOs) are provided in the SAP/QAPP (EPA 2012a). In brief, the purpose of the study was to collect data on LA concentrations in a variety of media from cities outside of the Libby Valley that are not expected to be affected by the Libby vermiculite mine which can provide a frame of reference for comparisons to exposures in Libby. The primary study objective was to measure LA concentrations in outdoor ABS air and other environmental source media (e.g. soil, tree bark, duff material) that can be used to compare to levels measured in Libby. Results can be used by risk managers to provide a frame of reference for the purposes of interpreting estimated exposures at the Site.

An overview of the study design developed to address these DQOs is summarized below.

3.1.1 Sampling Locations

3.1.1.1 Outside the Libby Valley

In order to provide a frame of reference for levels of LA observed in Libby, three cities outside of the Libby Valley, that are not expected to be affected by the Libby vermiculite mine, were selected for evaluation – Eureka, Helena, and Whitefish, Montana. In the past, the ambient air monitoring program for the Libby Site included stations in Eureka and Helena to provide reference data for ambient air (EPA 2009). Therefore, both of these cities were included in this sampling program as well. The city of Whitefish was selected for this investigation because it is one of the two nearest cities (Eureka being the second) in the predominant downwind direction (northeast) of the vermiculite mine (EPA 2008).

To avoid possible sampling access issues, sample collection areas near each city were selected in locations that are state or federally-owned. Three sampling locations at each city, identified as Area A, B, or C (e.g., Helena Area A), were sampled. These sampling locations were generally placed such that they were representative of various compass directions around each city. To minimize potential affects from anthropogenic sources and therefore be more representative of the range of background exposures, locations outside of the city limits were selected. Sampling locations were placed in areas that were accessible *via* forest service roads and that appeared to have adequate tree cover (based on a review of aerial images). Sampling locations for Eureka, Helena, and Whitefish are shown on **Figure 3-1.**

Samples of all media types were collected from each sampling location prior to mobilizing to other sampling locations in the same city. All sample collection efforts were completed for one city prior to mobilizing to the next city.

3.1.1.2 Inside the Libby Valley

An additional location south of Libby near Flower Creek was included as an addendum to this Comparative Exposure Investigation (EPA 2012b). The Flower Creek location is in a timber sale area (see **Figure 3-2**). This area is not a reference area, as it has the potential to be affected by the Libby vermiculite mine. However, it was included as part of this investigation to provide data on LA levels within the Libby Valley using the same sampling methods as used outside the Libby Valley.

3.1.2 Sampling Dates

Because the levels of LA in outdoor ABS air generated during soil disturbance scenarios may depend on factors that vary seasonally (e.g., soil moisture, wind speed, humidity), the Comparative Exposure Investigation targeted the summer months (July-September) for sampling, when rainfall and soil moisture levels are expected to be at their lowest. These conditions would result in a higher probability of measureable ABS air concentrations of LA, if it were present. Additional considerations in the selection of sampling dates were if rainfall exceeded ¼ inch in the past 36 hours, if there was standing water present, or if the moisture deficiency was less than 50%, sampling would not be performed. Based on these considerations, sampling was performed from August 7 to August 22, 2012.

3.2 Sample Collection Methods

At each sampling location, tree bark, duff material, soil composite samples, and two types of ABS air samples (one representative of a child digging and the other representative of an adult digging a fireline by hand), were collected (see **Table 3-1**). At each location, a 10-foot by 10-foot square area (100 square feet [ft^2]) was identified for the child digging ABS area and was used to guide the selection of sampling points for the various media types.

3.2.1 Tree Bark Samples

Sampling began with the collection of one tree bark composite sample from the area immediately surrounding the 100-ft^2 child digging ABS area. Tree bark samples were collected, handled, and documented in general accordance with Site-specific SOP EPA-LIBBY-2012-12, *Sampling and Analysis of Tree Bark for Asbestos*, and the investigation-specific modifications specified in the SAP/QAPP (EPA 2012a).

In brief, a hole saw and chisel were used to collect a circular bark sample (see **Figure 3-3**) from each of three trees at a height of about 4-5 feet above ground and then composited into a single sample for analysis of LA by transmission electron microscopy (TEM). Douglas firs with a diameter of at least 8 inches were selected for sampling at most locations; when Douglas firs were not available, other pine species (i.e., ponderosa pine) with rough bark were selected. Species with rough bark were preferred because it is expected that asbestos structures would have a higher potential for adherence to the bark surface if it is rough than if it is smooth. A total of 10 tree bark composite samples were collected (i.e., three tree bark composite samples per city for each of three cities, one composite sample for Flower Creek, and one field duplicate collected from Eureka Area C).

3.2.2 Duff Samples

Following tree bark collection, a 30-point composite sample (enough to fill a 1-gallon zip-top bag) of duff material (i.e., fresh or partially-decayed organic debris on the ground surface, including twigs, leaves, pine needles) was collected by hand from each 100-ft^2 child digging ABS area for analysis of LA by TEM. Samples of duff material were collected, handled, and documented in general accordance with Site-specific SOP EPA-LIBBY-2012-11, *Sampling and Analysis of Duff for Asbestos*. A total of 10 duff composite samples were collected (i.e., three duff composite samples per city for each of three cities, one composite sample for Flower Creek, and one field duplicate collected from Whitefish Area C).

3.2.3 Soil Samples

3.2.3.1 Collection Methodology

Following duff collection, surficial soil (1 to 6 inches) was collected within each 100-ft^2 child digging ABS area to serve as the composite soil sample and source material for the digging ABS activity. Soil samples were collected, handled, and documented in general accordance with Site-specific SOP CDM-LIBBY-05, *Site-Specific SOP for Soil Sample Collection*. Soil was collected from 30 sub-locations evenly distributed within each ABS area. A 5-gallon bucket was filled and then homogenized. An approximate 1,000 gram (g) soil sample was taken from the homogenized soil used to fill the 5-gallon bucket prior to ABS air sampling for the purposes of asbestos analysis. A total of 10 soil samples were collected for analysis of asbestos by TEM (i.e., three soil samples per city for each of three cities, one sample for Flower Creek, and one field duplicate).

3.2.3.2 Soil Moisture Content Evaluation

During soil sample collection and prior to the start of ABS air sampling, the soil moisture was determined. For the ABS child digging scenario, soil moisture was measured in the 5-gallon bucket of soil immediately prior to its use in the ABS scenario using a soil moisture meter. ABS activities were performed only if the measured volumetric water content (VWC) was less than 50%. In addition, soil moisture was estimated by the hand squeeze appearance method. In brief, this procedure is performed by firmly squeezing a handful of soil and observing how easily the soil forms a ball and breaks apart under pressure. A detailed description of this method is provided in the SAP/QAPP (EPA 2012a).

For the ABS fireline digging scenario, soil moisture was measured from 10 locations along the fireline between 0 and 3 inches below ground surface using a soil moisture meter. ABS activities were performed only if the average measured VWC was less than 50%.

3.2.3.3 Soil Visual Inspection

At the time of soil sample collection, the sampling team performed a visual inspection of the displaced soil at each of the 30 sub-location points to determine if visible vermiculite was present in general accordance with SOP CDM-LIBBY-06, *Semi-Quantitative Visual Estimation of Vermiculite in Soils at Residential and Commercial Properties*. A semi-quantitative estimate (none, low, moderate[2], high) of the amount of visible vermiculite present was noted for each sampling point. A count of the number of sampling points assigned to each visible vermiculite ranking was recorded on the FSDS form (e.g., 18 none [X], 6 low [L], 4 moderate [M], 2 high [H]).

3.2.4 ABS Air Samples

People may disturb soil or other LA-contaminated source materials by a variety of different activities. It is not feasible to evaluate every possible type of disturbance, so ABS was performed using selected scenarios considered to be representative examples of disturbances that have been evaluated in other outdoor ABS programs at the Site. Two different types of ABS scenarios were evaluated – a child digging scenario (simulating a child digging in dirt) and a fireline digging scenario (simulating a fire fighter digging a fireline by hand). These scenarios were considered realistic examples of relatively vigorous soil disturbance activities.

During each disturbance scenario, the individual performing the activity wore two personal air monitors (high volume [HV] and low volume [LV]) to collect air samples for asbestos analysis. The filter cassette for each monitor was placed such that the samples collected were representative of the breathing zone of the individual performing the disturbance activity (i.e., a hemisphere approximately 6 to 9 inches around an individual's face). Only one of the two resulting air samples from each actor was selected for analysis (either the HV or the LV filter). During the ABS event, pump flow rates were verified at 30-minute intervals or when participants are relieved from an activity by a backup participant, whichever occurs first.

ABS air samples were collected, handled, and documented in general accordance with Site-specific SOP EPA-LIBBY-2012-10, *Sampling of Asbestos Fibers in Air*. The following subsections describe air sample collection for each ABS scenario in more detail.

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[2] The visual inspection SOP CDM-LIBBY-06 uses the terminology "intermediate" to refer to the "moderate" classification. For the purposes of this document, the term "moderate" was retained to correspond with the accompanying ABS field documentation.

3.2.4.1 Child Digging ABS Scenario

Following soil collection, the child digging ABS air sampling event was conducted on a tarp near the child digging ABS area using the soil from the 5-gallon bucket (see **Figure 3-4**). This type of ABS digging scenario was originally evaluated as part of the *2011 Miscellaneous ABS SAP for OU4* (EPA 2011a). This digging scenario simulates a child playing and digging in the dirt. It is a standardized simulation scenario considered to be a realistic example of vigorous soil disturbance activities. In brief, at each ABS area, a 5-gallon bucket of soil was collected (as described above) and brought to the location where the ABS was to be conducted. ABS personnel would sit on a tarp on the ground and empty the soil from the 5-gallon container onto the ground; then, using a hand trowel they place the soil back into the container (see **Figure 3-4**). Once all the soil was placed back into the container the process was repeated. This procedure was repeated for 120 minutes. As noted above, each ABS event included collection of two ABS air samples – one with a HV pump and one with an LV pump. The HV sample was collected using a pump flow rate of approximately 5.5 liters per minute (L/min) and the LV sample was collected using a pump flow rate of approximately 2.0 L/min. This resulted in total air sample volumes for the HV digging ABS sample and the LV digging ABS sample of approximately 660 liters (L) and 240 L, respectively.

A total of 20 digging ABS air samples were collected (six ABS air samples per city for each of three cities and two for Flower Creek). Only one of the two air filters for each ABS sample, either the HV or the LV, was analyzed for LA by TEM (see Section 3.3.1.1).

3.2.4.2 Fireline Digging ABS Scenario

Following the child digging ABS scenario, the fireline digging ABS scenario was conducted in the general vicinity of the child digging ABS area. This type of ABS scenario was originally evaluated as part of the *Phase IV Part A SAP for Libby OU3* (EPA 2010). The fireline ABS scenario simulates firefighters constructing a firebreak by hand resulting in disturbances of duff and soil. During this ABS scenario, a Pulaski tool was used to scrape away all combustible material down to mineral soil to establish a fireline approximately 18 inches wide. This scenario is designed to simulate activities that are typically performed by a crew of four to six firefighters during an initial attack on a forest fire.

For the fireline digging ABS scenario, two individuals, working about 10 feet apart, performed firebreak activities for a period of 30 minutes (see **Figure 3-5**). After 15 minutes, ABS personnel reversed their relative positions. As noted above, each ABS event included collection of two ABS air samples – one with a HV pump and one with an LV pump. The HV sample was collected using a pump flow rate of approximately 5.5 L/min and the LV sample was collected using a pump flow rate of approximately 2.0 L/min. The total air sample volumes for the HV fireline ABS sample and the LV fireline ABS sample were approximately 165 L and 60 L, respectively.

A total of 40 fireline ABS air samples were collected (12 ABS air samples per city for each of three cities and two for Flower Creek). Only one of the two air filters for each ABS sample, either the HV or the LV, was analyzed for LA by TEM (see Section 3.3.1.1).

3.3 Preparation and Analysis Methods

3.3.1 ABS Air Samples

All outdoor ABS air samples were submitted to one of the subcontracted Libby laboratories for asbestos analysis by TEM. Detailed information on sample preparation, analysis methods, and results reporting is provided below.

3.3.1.1 Sample Preparation

As noted above, two filters were collected for each ABS actor during each sampling scenario – one HV filter and one LV filter. The HV filter was analyzed in preference to the LV filter. If the HV filter was deemed to be overloaded (i.e., > 25% particulate loading on the filter), the LV filter was analyzed in preference to performing an indirect preparation on the HV filter. If the LV filter was also deemed to be overloaded, an indirect preparation (with ashing) was performed of the HV filter in accordance with the procedures in Libby-specific SOP EPA-LIBBY-08, *Indirect Preparation of Air and Dust Samples for Analysis by TEM*. For this investigation, the HV filter was analyzed for the majority of the ABS air samples; only three ABS samples out of thirty were prepared indirectly by ashing. A discussion of the potential influence of indirect preparation techniques on reported TEM air concentrations is presented in Section 5.5.5.

The selected filter was used to prepare a minimum of three grids using the grid preparation techniques described in Section 9.3 of ISO 10312:1995(E) (ISO 1995).

3.3.1.2 Analysis Methods

Analysis Requirements

The prepared grids for each ABS sample were analyzed by TEM in basic accordance with the counting and recording rules specified in ISO 10312:1995(E), as modified by the most recent versions of Libby Laboratory Modifications[3] LB 000016, LB-000029, LB-000066, LB-000067, and LB-000085.

During the TEM analysis, the analyst records the size (length, width) and mineral type of each individual asbestos structure that is observed. Mineral type is determined by selected area electron diffraction (SAED) and energy dispersive spectroscopy (EDS), and each structure is assigned to one of the following four categories:

[3] Copies of Libby Laboratory Modifications are available in the Libby eRoom.

LA *Libby-class amphibole.* Structures having an amphibole SAED pattern and an elemental composition similar to the range of fiber types observed in ores from the Libby mine (Meeker *et al.* 2003). This is a solid solution series of minerals including winchite, richterite, and tremolite, with lower amounts of magnesio-arfvedsonite, magnesio-riebeckite, and edenite/ferro-edenite. Depending on the valence state of iron, some minerals may also be classified as actinolite.

OA *Other amphibole-type asbestos fibers.* Structures having an amphibole SAED pattern and an elemental composition that is not similar to fiber types from the Libby mine. Examples include crocidolite, amosite, and anthophyllite. There is presently no evidence that these fibers are associated with the Libby mine.

CH *Chrysotile fibers.* Structures having a serpentine SAED pattern and an elemental composition characteristic of chrysotile. There is presently no evidence that these fibers are associated with the Libby mine.

NAM *Non-asbestos material.* These may include non-asbestos mineral fibers such as gypsum, glass, or clay, and may also include various types of organic and synthetic fibers derived from carpets, hair, etc.

In addition, information on the sodium and potassium content and mineral identification (e.g., winchite, tremolite), as determined by EDS, of each amphibole asbestos structure observed was also recorded.

Counting and Stopping Rules

When analyzing ABS air samples, grid openings were examined under low magnification (~5,000x) and only those asbestos structures that met phase contrast microscopy (PCM) counting rules (i.e., length > 5 micrometers [µm], width ≥ 0.25 µm, aspect ratio ≥ 3:1) were recorded. For convenience, structures that are indentified under TEM that meet PCM counting rules are referred to as PCM-equivalent (PCME). Asbestos air concentrations must be expressed as PCM or PCME in order to perform risk calculations.

The SAP/QAPP (EPA 2012a) provides detailed information on the derivation of the stopping rules for ABS air samples analyzed by TEM. The stopping rules were as follows:

1. Examine a minimum of two grid openings from each of two grids.
2. Continue examining grid openings until one of the following is achieved:
    a. The target analytical sensitivity is achieved (i.e., digging ABS scenario = 0.00022 cc^{-1}, fireline ABS scenario = 0.0025 cc^{-1}).
    b. 25 PCME LA structures have been observed.
    c. A total filter area of 20 square millimeters (mm^2) has been examined (this is

approximately 2,000 grid openings).

When one of these criteria was satisfied, the analyst was instructed to complete the examination of the final grid opening and stop.

For lot blanks and field blanks, the TEM analyst examined an area of 1.0 mm^2 (approximately 100 grid openings).

3.3.1.3 Calculation of Air Concentration

In this document, ABS air concentrations are expressed in units of PCME LA structures per cubic centimeter of air (s/cc). The concentration of LA in air is given by:

$$C_{air}\ (s/cc) = N \cdot S$$

where:

N = Number of PCME LA structures observed
S = Sensitivity (cc^{-1})

For air, the sensitivity is calculated as:

$$S = \frac{EFA}{GO \cdot Ago \cdot V \cdot 1000 \cdot F}$$

where:

S = Sensitivity for air (cc^{-1})
EFA = Effective area of the filter (mm^2)
GO = Number of grid openings examined
Ago = Area of a grid opening (mm^2)
V = Volume of air passed through the filter (L)
1000 = Conversion factor (cc/L)
F = Fraction of primary filter deposited on secondary filter (indirect preparation only; F = 1 for directly prepared filters)

3.3.2 Soil Samples

All soil samples were submitted to the Soil Preparation Facility (SPF) in Troy, Montana for processing using the fluidized bed asbestos segregator (FBAS). The FBAS preparation method utilizes air elutriation to separate asbestos structures from heavier soil matrix particles and deposit these structures onto a filter which can then be analyzed by TEM. This preparation method allows the TEM analysis to achieve detection limits that are approximately 100-times lower other analytical methods for soil (Januch *et al.* 2013).

Once processed, the resulting FBAS filters were sent to the subcontracted Libby laboratories for asbestos analysis by TEM. Detailed information on sample preparation, analysis methods, and results reporting is provided below.

3.3.2.1 Sample Preparation

At the Troy SPF, soil samples were dried as detailed in Libby-specific SOP ISSI-LIBBY-01, *Soil Sample Preparation.* Once dried, each sample was split into two approximately equal portions: 1) archive aliquot; 2) FBAS aliquot. The archive aliquot was stored in accordance with SOP ISSI-LIBBY-01.

The FBAS aliquot was prepared for analysis in accordance with SOP ESAT-LIBBY-01, *Fluidized Bed Asbestos Segregator Method for Determination of Releasable Asbestos Fibers in Soil*. In brief, the soil aliquot was sieved using sieves with two opening sizes (6.3-mm and 0.85-mm). Soil material passing through the 0.85-mm sieve was retained for use in the FBAS. For each soil sample, three FBAS filter replicates were generated. Each FBAS filter was generated using approximately 5 grams of soil in the FBAS, with the goal of intentionally overloading the filter. These FBAS filters were analyzed for asbestos by TEM by three different laboratories, with each laboratory receiving one of the replicate filters.

At the TEM laboratory, the FBAS filters were prepared using the "rock flour" technique developed by the Environmental Services Assistance Team (ESAT) Region 8 laboratory (TechLaw, Inc. 2011). In brief, filters were ashed using the same procedures described in SOP EPA-LIBBY-08. The resulting ashed residue was suspended in water, sonicated, and the suspension was allowed to settle in a graduated cylinder for 3 hours. Then, an aliquot of the top portion of the suspension was placed onto a new filter. This filter was used to prepare a minimum of three grids using the grid preparation techniques described in Section 9.3 of ISO 10312:1995(E).

3.3.2.2 Analysis Methods

Grids were examined by TEM in basic accordance with the recording procedures described in ISO 10312:1995(E), as modified by the most recent versions of Libby Laboratory Modifications LB-000016, LB-000029, LB-000066, LB-000067, and LB-000085.

During the TEM analysis, the analyst recorded the mineral class (LA, OA, CH, NAM), size (length, width), and information on sodium and potassium content and mineral identification for each individual countable asbestos structure that was observed.

To reduce the potential level of effort to complete the TEM analysis, grid openings were examined using a tiered approach, as follows:

High Magnification Analysis

The TEM microscopist begins the analysis utilizing a magnification of 20,000x. All amphibole structures (including not only LA but all OA asbestos types as well) that have appropriate SAED patterns and EDS spectra, and having length ≥ 0.5 µm and an aspect ratio ≥ 3:1 are recorded on the FBAS-specific TEM laboratory bench sheets and EDD spreadsheets. If observed, chrysotile structures are recorded, but chrysotile structure counting may stop after 50 structures have been recorded.

A minimum of two grid openings from each of two grids are examined. Examination of grid openings continues until one of the following is achieved:

1. The target analytical sensitivity (6.3E+03 per gram [g^{-1}]) is achieved,
2. 50 LA structures are recorded, or
3. A total area of 1.6 mm^2 of filter has been examined (approximately 160 grid openings).

When one of these criteria is achieved, the final grid opening is completed and the analysis is ended.

Low Magnification Analysis

After completing the initial examination at 20,000x magnification, if fewer than 50 LA structures are recorded, and the target analytical sensitivity has not yet been achieved, the TEM microscopist switches to a lower magnification of 5,000x and continues to record only PCME LA structures (i.e., length > 5 µm, width ≥ 0.25 µm, aspect ratio ≥ 3:1) until one of the following is achieved:

1. The target analytical sensitivity (6.3E+03 g^{-1}) is achieved,
2. 50 LA structures are recorded, or
3. A total area of 3.0 mm^2 of filter has been examined (approximately 300 grid openings).

When one of these criteria is achieved, the final grid opening is completed and the analysis is ended.

For blanks (lot blanks, preparation blanks, and sand blanks), the TEM analyst examined an area of 1.0 mm^2 (approximately 100 grid openings) utilizing a magnification of 20,000x and the counting rules described above for the "high magnification analysis".

3.3.2.3 Calculation of Soil Concentration

The results for each FBAS soil analysis are expressed in terms of LA structures per gram soil, on a dry weight basis (s/g). The basic formula for calculating concentration is as follows

$$C_{soil}\ (s/g) = (N \cdot EFA) / (GOx \cdot Ago \cdot M \cdot Q_R \cdot F)$$

where:

N = Number of LA structures counted
EFA = Effective filter area (mm^2)
Q_R = Flow ratio; this is the fraction of air passed through the soil sample (V_{total}) that is captured on the air filter (V_{filter}), and is calculated as:

$$Q_R = V_{filter} / V_{total}$$

GOx = Number of grid openings evaluated
Ago = Area of one grid opening (mm^2)
M = Mass of soil placed in the FBAS (g)
F = Fraction of the total suspension volume applied to the secondary filter, calculated as:

$$F = A/V$$

where:

A = Volume of suspension applied to filter (mL)
V = Total suspension volume (mL)

3.3.2.4 Combining Results from Multiple Filter Replicates

The best estimate of the mean concentration across FBAS filter replicates is calculated simply by averaging the individual concentration values. Note that replicates with a count of zero (and hence a concentration of zero) are evaluated as zero when computing the best estimate of the mean (EPA 2008). This approach yields an unbiased estimate of the true mean that does not depend on the analytical sensitivity of the samples included in the data set.

3.3.3 Duff Samples

All duff samples were submitted to one of the subcontracted Libby laboratories for sample preparation and asbestos analysis by TEM. Detailed information on sample preparation, analysis methods, and results reporting are provided below.

3.3.3.1 Sample Preparation

Duff samples were prepared and analyzed in basic accordance with the procedures specified in SOP EPA-LIBBY-2012-11, *Sampling and Analysis of Duff for Asbestos*. In brief, each sample is dried and ashed, and an aliquot of the resulting ash residue is acidified, suspended in water, and filtered. A total of three replicate filters were created for each duff sample using multiple aliquots of the ash residue. Each filter was used to prepare a minimum of three grids using the grid preparation techniques described in Section 9.3 of ISO 10312:1995(E).

3.3.3.2 Sample Analysis

Grids were examined by TEM using high magnification (~20,000x) in basic accordance with the recording procedures described in ISO 10312:1995(E), as modified by SOP EPA-LIBBY-2012-11 and the most recent versions of Libby Laboratory Modifications LB-000016, LB-000029, LB-000066, LB-000067, and LB-000085. In brief, all fibrous amphibole structures that have appropriate SAED patterns and EDS spectra, and having length ≥ 0.5 um and an aspect ratio (length: width) ≥ 3:1, were recorded. If observed, chrysotile structures were recorded using the same procedures.

During the TEM analysis, the analyst recorded the mineral class (LA, OA, CH, NAM), size (length, width), and information on sodium and potassium content and mineral identification for each individual countable asbestos structure that was observed.

The stopping rules for the TEM analysis of duff materials are as follows:

1. Examine a minimum of two grid openings from each of two grids.
2. Continue examining grid openings until one of the following is achieved:
   a. The target analytical sensitivity (1E+07 per gram dry weight [g^{-1}]) is achieved.
   b. 50 LA structures have been observed.
   c. A total filter area of 1.0 mm^2 has been examined (this is approximately 100 grid openings).

When one of these criteria has been satisfied, complete the examination of the final grid opening and stop.

3.3.3.3 Calculation of Duff Concentrations

The results for each duff analysis are expressed in terms of LA structures per gram duff on a dry weight basis (s/g). The basic formula for calculating concentration is as follows:

$$C_{duff}\ (s/g) = (N \cdot EFA) / (GO \cdot Ago \cdot Mass \cdot F)$$

where:

N = Number of total LA structures observed
EFA = Effective filter area (mm^2)
GO = Number of grid openings counted
Ago = Area of one grid opening (mm^2)
Mass = Mass of the dried (but not ashed) duff sample (g)
F = Fraction of the dried duff sample applied to the filter, calculated as:

$$F = M_a / M_t \cdot V_a / V_t$$

where:

M_a = Mass of ash aliquot used in the suspension (g)
M_t = Total mass of ash (g)
V_a = Volume of suspension applied to filter (mL)
V_t = Total suspension volume (mL)

3.3.3.4 Combining Results from Multiple Filter Replicates

The best estimate of the mean duff concentrations across filter replicates is calculated simply by averaging the individual concentration values. Note that samples with a count of zero (and hence a concentration of zero) are evaluated as zero when computing the best estimate of the mean (EPA 2008).

3.3.4 Tree Bark Samples

All tree bark samples were submitted to one of the subcontracted Libby laboratories for sample preparation and asbestos analysis by TEM. Detailed information on sample preparation, analysis methods, and results reporting are provided below.

3.3.4.1 Sample Preparation

Tree bark samples were prepared and analyzed in basic accordance with the procedures specified in SOP EPA-LIBBY-2012-12, *Sampling and Analysis of Tree Bark for Asbestos*. In brief, each sample is dried and ashed, and the resulting ash residue is acidified, suspended in water, and filtered. A total of three replicate filters were created for each tree bark sample using equal aliquots of the ash residue suspension. Each filter was used to prepare a minimum of three grids using the grid preparation techniques described in Section 9.3 of ISO 10312:1995(E).

3.3.4.2 Sample Analysis

Grids were examined by TEM using high magnification (~20,000x) in basic accordance with the recording procedures described in ISO 10312:1995(E), as modified by SOP EPA-LIBBY-2012-12. In brief, all fibrous amphibole structures that have appropriate SAED patterns and EDS spectra, and having length ≥ 0.5 um and an aspect ratio (length: width) ≥ 3:1, were recorded. If observed, chrysotile structures were recorded using the same procedures.

During the TEM analysis, the analyst recorded the mineral class (LA, OA, CH, NAM), size (length, width), and information on sodium and potassium content and mineral identification for each individual countable asbestos structure that was observed.

The stopping rules for the TEM analysis of tree bark are as follows:

1. Examine a minimum of two grid openings from each of two grids.
2. Continue examining grid openings until one of the following is achieved:
    a. The target analytical sensitivity (100,000 per square centimeter [cm^{-2}]) is achieved.
    b. 50 LA structures have been observed.
    c. A total filter area of 1.0 mm^2 has been examined (this is approximately 100 grid openings).

When one of these criteria has been satisfied, complete the examination of the final grid opening and stop.

3.3.4.3 Calculation of Tree Bark Surface Loading

The results for each tree bark analysis are expressed in terms of LA structures per cm^2 of tree bark (s/cm^2) (i.e., a surface area loading). The basic formula for calculating surface loading is as follows:

$$L_{treebark}\,(s/cm^2) = (N \cdot EFA) / (GO \cdot Ago \cdot A \cdot F)$$

where:

N = Number of total LA structures observed
EFA = Effective filter area (square millimeters [mm^2])
GO = Number of grid openings counted
Ago = Area of one grid opening (mm^2)
A = Area of tree bark sample being analyzed (cm^2), calculated as:

$$A = N \cdot [(\pi \cdot (D_c/2)^2) - (\pi \cdot (D_p/2)^2)]$$

where:

N = number of cores
π = pi (3.14159265…)
D_c = diameter of the core (cm)
D_p = diameter of the pilot hole (cm)

F = Fraction of original sample deposited on the filter, calculated as:

$$F = M_a/M_t \cdot V_a/V_t$$

where:

M_a = Mass of ash aliquot used in the suspension (g)
M_t = Total mass of ash (g)
V_a = Volume of suspension applied to filter (mL)
V_t = Total suspension volume (mL)

3.3.4.4 Combining Results from Multiple Filter Replicates

The best estimate of the mean tree bark surface loadings across filter replicates is calculated simply by averaging the individual surface loading values. Note that samples with a count of zero (and hence a surface loading of zero) are evaluated as zero when computing the best estimate of the mean (EPA 2008).

4 Comparative Exposure Investigation Results and Evaluation

4.1 *Results*

Appendix C presents the detailed raw data for all samples collected as part of the Comparative Exposure Investigation that were analyzed by TEM. Results for each environmental medium are described below.

4.1.1 Soil

4.1.1.1 Asbestos

As discussed previously, the level of asbestos in soil at each ABS area was characterized using two alternative soil metrics (visible vermiculite inspection and TEM). Visible vermiculite was not observed at any of the soil sample locations in any exposure area. **Table 4-1** presents the results of the TEM analysis of soil samples following preparation with the FBAS. Results are expressed based on total LA and discussed below.

Outside Libby Valley (Eureka, Helena, Whitefish)

For the soil samples collected from outside of the Libby Valley (i.e., Eureka, Helena, Whitefish), total LA structures were observed in one or more replicates for every city. On average, soil concentrations ranged from about 3E+03 to 7E+04 total LA s/g. Based on the LA-specific regression equation presented in Januch *et al.* (2013), this is lower than about 0.003% by mass.

The LA structures observed were ranked as being characteristic of actinolite (AC) or tremolite (TR) and no sodium or potassium (XX) was noted in the EDS spectra for these structures. According to Meeker *et al.* (2003), asbestos structures originating from the Libby vermiculite ore body contain detectable levels of both sodium and potassium, whereas other potential sources of LA may not. This would indicate that the asbestos structures observed in these soils do not originate from the vermiculite ore deposit at the Libby mine site.

Inside Libby Valley (Flower Creek)

For the soil sample collected from Flower Creek inside the Libby Valley, the average soil concentration was 3E+05 total LA s/g. Nearly all of the LA structures observed were characterized as being part of the solid solution series of winchite, richterite,tremolite, and actinolite (WRTA), and had EDS spectra that showed the LA structures contained sodium and potassium (NaK), which is supportive of the conclusion that they are derived from the Libby vermiculite ore deposit (Meeker *et al.* 2003).

4.1.1.2 Soil Moisture

Soil moisture was measured by a soil moisture meter and the hand squeeze appearance method in the composite bucket of dirt used for the digging scenario; results are summarized in **Table 4-2**. Soil moisture was measured at 10 locations within each fireline ABS area using a soil moisture meter; the average for each fireline ABS area is summarized in **Table 4-2**. As seen, soil moisture measurements were less than 50% and therefore met the DQO requirements to perform ABS.

4.1.2 ABS Air

Table 4-3 presents the results of the ABS air samples, stratified by sampling location and ABS disturbance scenario. As shown, no PCME LA structures were observed in any of the ABS air samples. These results demonstrate that, despite the fact that detectable levels of asbestos were noted in soil, active disturbances of these soils did not result in detectable releases of PCME LA to air.

4.1.3 Tree Bark

Table 4-4 (Panel A) presents the results of the tree bark samples, stratified by ABS area. As shown, no LA structures were observed during the TEM analysis in any of the tree bark samples collected from sample locations in Helena, Whitefish, or Eureka. However, LA structures were observed in two of the three replicate filters for tree bark samples from Flower Creek. The average surficial loading level of LA on tree bark in Flower Creek was 0.06 million LA structures per square centimeter of bark surface (Ms/cm^2). In the Flower Creek replicates, the three LA structures observed had EDS spectra that showed they contained sodium and potassium (NaK).

4.1.4 Duff

Table 4-4 (Panel B) presents the results of the duff samples, stratified by ABS area. As shown, no LA structures were observed during the TEM analysis in any of the duff samples collected from sample locations in Helena, Whitefish, or Eureka. However, LA was observed in one of the three replicate filters for duff samples from Flower Creek. The average concentration of LA in duff from Flower Creek was 2.7 million structures per gram of duff on a dry weight basis (Ms/g, dw). The one LA structure observed had an EDS spectrum that showed it contained sodium and potassium (NaK).

4.2 Summary and Discussion

In this investigation, tree bark, duff, soil, and ABS air samples were collected from locations surrounding the cities of Helena, Whitefish, and Eureka, and the Flower Creek area outside of Libby in order to provide a frame of reference for exposures to asbestos in Libby. Outdoor ABS air samples and environmental source media were collected from 3 different areas surrounding each city and from one area at Flower Creek resulting in a total of 10 outdoor ABS sampling areas. Sample collection activities were performed in August 2012.

To provide exposure references for Libby, two different types of ABS scenarios were evaluated – a child digging ABS scenario (simulating a child digging) and a fireline digging ABS scenario (simulating a fire fighter digging a fireline by hand). A total of 10 ABS air samples were analyzed for the child digging scenario and 20 ABS air samples were analyzed for the fireline digging scenario. No PCME LA structures were observed during the TEM analysis for any of the ABS air samples for any ABS area.

No visible vermiculite was noted by the field teams in any of the collected soil samples. Low levels of LA were measured in soils (following preparation by FBAS and analysis by TEM) from Eureka, Helena, and Whitefish; however, the underlying chemistry of the asbestos structures in these samples suggests that they do not originate from the vermiculite ore deposit at the Libby mine site.

LA was also detected in soils from Flower Creek area, at concentrations about 10 times higher than in soils from cities outside the Libby Valley (i.e., Eureka, Helena, and Whitefish). The LA structures observed in Flower Creek soils were characterized as containing sodium and potassium (NaK), which suggests that they originated from the Libby vermiculite ore deposit.

No LA structures were observed in any of the tree bark or duff samples collected in Helena, Whitefish, or Eureka. Low levels of LA were detected in tree bark and duff samples from Flower Creek, and the LA structures observed were characterized as containing sodium and potassium (NaK), which suggests that they originated from the Libby vermiculite ore deposit.

5 Data Quality Assessment

Data quality assessment (DQA) is the process of reviewing existing data to establish the quality of the data and to determine how any data quality limitations may influence data interpretation (EPA 2006).

5.1 *Audits*

5.1.1 Field Audits

Field audits are conducted to evaluate field personnel in their day-to-day activities and ensure all processes and procedures are performed in accord with the applicable field guidance documents (or approved Libby Field Office [LFO] modification forms) to make certain that samples collected are correct and consistent. All aspects of data documentation and sample collection, as well as sample handling, custody, and shipping are evaluated. If any issues are identified, field personnel are notified and retrained as appropriate. A field audit was to be conducted as specified in the SAP/QAPP (EPA 2012a). However, it was subsequently determined, based on consultation with CDM Smith quality assurance (QA) staff, the field audit was not necessary because of the short duration of this event and the fact that the types of ABS scenarios conducted for this investigation had been performed previously by the same team without issue.

5.1.2 Laboratory Audits

Laboratory audits are conducted to evaluate laboratory personnel to ensure that samples are handled and analyzed in accord with the program-specific documents and analytical method requirements (or approved Libby laboratory modification forms) to make certain that analytical results reported are correct and consistent. All aspects of sample handling, preparation, and analysis are evaluated. If any issues are identified, laboratory personnel are notified and retrained as appropriate.

A series of laboratory audits was performed in May through September 2012 to evaluate all of the Libby laboratories. Detailed audit findings for each laboratory are documented in separate laboratory-specific audit reports (CB&I Federal Services, LLC [CB&I], formerly Shaw Environmental & Infrastructure Group [Shaw E&I] 2012a-g). No critical deficiencies were noted during the 2012 laboratory audits that would be expected to impact data quality for TEM analyses.

5.2 *Modifications*

During any sampling investigation, deviations from the original SAP/QAPP may occur and/or it may be necessary to modify procedures identified in the original SAP/QAPP and/or SOPs to optimize sample collection. At the Libby Site, all field and laboratory modifications are recorded in Site-specific modification forms. These forms provide a standardized format for tracking procedural changes in sample collection and analysis and allow project managers to assess potential impacts on the quality of the data being collected.

During the Comparative Exposure Investigation, one field modification (LFO-000168) was created that documented changes from sample collection and analysis methodology specified in the SAP/QAPP (EPA 2012a). **Appendix D** provides a copy of LFO-000168. **Table 5-1** summarizes the content of this modification and notes the anticipated impact of each deviation on the quality and usability of the data. As indicated, none of the modifications are expected to have a negative impact on data quality or usability. No laboratory modifications were created for samples collected as part of this study.

5.3 Data Verification and Data Validation

The Libby Scribe project databases have a number of built-in quality control checks to identify unexpected or unallowable data values during upload into the database. Any issues identified by these automatic upload checks were resolved by consultation with the field teams and/or analytical laboratory before entry of the data into the database. After entry of the data into the database, several additional data verification steps were taken to ensure the data were recorded and entered correctly.

5.3.1 Data Verification

In order to ensure that the database accurately reflects the original hard copy documentation, all data downloaded from the database were examined to identify data omissions, unexpected values, or apparent inconsistencies. In addition, 100% of all sample information and analytical results underwent a detailed verification. In brief, verification involves comparing the data for a sample in the database to information on the original hard copy FSDS form or the original hard copy analytical bench sheets for that sample. The following subsections detail the types and results of the data verification efforts that have been performed for this investigation.

5.3.1.1 FSDS Verification Review

Hard copy FSDS forms were reviewed in accordance with SOP EPA-LIBBY-11 for all field samples – 30 ABS air samples, 10 soil samples, 10 duff samples, and 10 tree bark samples – as part of the data verification effort. **Appendix E** presents a summary of the findings of the FSDS review for the Comparative Exposure Investigation.

In general, most of the issues identified were important for the purposes of sample tracking (e.g., air type, personnel ID number, FSDS form number), but would not have influenced the quantitative analytical results reported for the sample. However, the recorded air pump stop time was incorrect for two ABS air samples, which influenced the calculated total air sample volume. As a consequence of this field error, the analytical laboratory had to examine additional grid openings in order to reach the target analytical sensitivity for these two samples.

5.3.1.2 TEM Verification Review

TEM analyses were reviewed in accordance with SOP EPA-LIBBY-09 as part of the data verification effort. Laboratory EDDs were reviewed for all field samples (i.e., 120 TEM analyses of ABS air, FBAS soil, duff, and tree bark) as part of the verification effort. **Appendix E** presents a summary of the findings of the TEM verification for the Comparative Exposure Investigation.

In general, most of the issues identified were non-critical in nature from a data interpretation perspective. The majority of the issues were related to data entry errors in the magnification, instrument identifier, analysis date, analysis tag, grid opening name, etc. fields in the EDD. Critical[4] errors were noted in five FBAS soil analyses and two tree bark analyses. For the five FBAS soil analyses, the laboratory entered the incorrect total suspension volume in the EDD, which influenced the achieved analytical sensitivity. As a consequence of this error, the analytical laboratory had to examine additional grid openings in order to reach the target analytical sensitivity for these five samples. For the two tree bark analyses, the laboratory entered the incorrect bark core diameter in the EDD, which influenced the achieved analytical sensitivity and reported surface loading; however, no re-analysis was required as the achieved analytical sensitivity was adequate. The laboratory submitted corrected EDDs for both tree bark analyses.

5.3.1.3 Verification Conclusions

All issues identified during the data verification effort were submitted to the field teams and/or analytical laboratories for resolution and rectification. All tables, figures, and appendices (including all hard copy documentation, the Access database, and detailed data summary [provided in **Appendices A through C**, respectively]) generated for this report reflect corrected data. Because 100% of this dataset was verified and all identified issues were resolved, there are no impacts on data quality due to these verification issues.

5.3.2 Data Validation

Unlike data verification, where the goal is to identify and correct data reporting errors, the goal of data validation is to evaluate overall data quality and to assign data qualifiers, as appropriate, to alert data users to any potential data quality issues.

Data validation is performed by the EPA Quality Assurance Technical Support (QATS) contractor (CB&I), with support from technical support staff that are familiar with investigation-specific data reporting, analytical methods, and investigation requirements. For the Libby project, data validation of TEM results is performed in accordance with Libby-specific

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[4] A critical discrepancy is defined as an issue that could influence the reported sample concentration.

SOPs developed based on the draft *National Functional Guidelines (NFG) for Asbestos Data Review* (EPA 2011b).

The EPA QATS contractor prepares an annual summary of the program-wide assessment of quality assurance/quality control (QA/QC). This annual addendum provides detailed information on the validation procedures performed and provides a narrative on the quality assessment for each type of analysis (e.g., TEM), including the data qualifiers assigned and the reason(s) for these qualifiers to denote when results do not meet acceptance criteria. This annual summary details any deficiencies, required corrective actions, and makes recommendations for changes to the QA/QC program to address any data quality issues.

A copy of the program-wide QA/QC summary report covering samples collected and analyzed in 2010-2012 (CB&I 2013) is currently pending. When this report is finalized, it will be located on the Libby Lab eRoom. Interpretation of the data quality is subject to change upon completion of this report.

5.4 Quality Control Summary

A number of quality control (QC) samples and analyses were collected as part of the ABS program to help characterize the accuracy and precision of the data obtained. QC samples included both field-based samples (which are submitted blind to the laboratories) and laboratory-based samples.

5.4.1 Field Quality Control

5.4.1.1 Blanks

Two types of blanks were collected as part of this outdoor ABS air program – lot blanks and field blanks.

Lot blanks are collected to ensure air samples for asbestos analysis are collected on asbestos-free filters. Only filter lots with acceptable lot blank results (i.e., no asbestos structures detected) were placed into use for this investigation.

Field blanks are collected to evaluate potential contamination introduced during sample collection, shipping and handling, or analysis. For this investigation, a total of three field blanks were analyzed by TEM. No asbestos structures were observed on any field blanks (a filter area of about 1.0 mm^2 was examined for each blank). These results support the conclusion that inadvertent contamination of air samples with LA is not of significant concern, either in the field or the laboratory.

5.4.1.2 Field Duplicates

Field duplicates for soil, tree bark, and duff samples were collected at a rate of 1 field duplicate per 10 field samples, in accordance with the frequency specified in the Comparative Exposure SAP/QAPP. A total of 1 field duplicate for each medium (out of 10 field samples) was collected. The original and field duplicate sample results were compared using the Poisson ratio test recommended by Nelson (1982). For tree bark and duff, the original and field duplicate samples were both non-detect; thus, the results are not different. For soil, the original and field duplicate samples were compared based on the pooled concentration across FBAS filter replicates. As shown in **Table 5-2**, results were not statistically different based on the Poisson ratio comparison (90% confidence interval). These results show that inherent variability due to sampling methods and small-scale media heterogeneity are not likely to alter data conclusions.

5.4.2 Laboratory Quality Control

The Libby-specific QC requirements for TEM analyses of asbestos are patterned after the requirements set forth by the National Voluntary Laboratory Accreditation Program (NVLAP). In brief, there are three types of laboratory-based QC analyses for TEM – laboratory blanks, recounts, and repreparations. Detailed information on the Libby-specific requirements for each type of TEM QC analysis, including the minimum frequency rates, selection procedures, acceptance criteria, and corrective actions are provided in the most recent version of Libby Laboratory Modification LB-000029.

Laboratory QC analyses will be evaluated by the EPA QATS contractor on a program-wide basis rather than on an investigation-specific basis. The rationale for this is that the number of laboratory QC samples directly related to this investigation is too limited to draw meaningful conclusions regarding overall data quality. However, a cursory review of recount analyses performed for ABS air, tree bark, duff and FBAS soil samples collected as part of the Comparative Exposure Investigation show that within-laboratory TEM results are reproducible and reliable. However, this cursory review did not include an evaluation of inter-laboratory analyses.

Refer to the pending program-wide QA/QC summary report covering samples collected and analyzed in 2010-2012 (CB&I 2013) for information regarding program-wide data quality of the preparation and analytical laboratories. As noted previously, interpretation of the data quality is subject to change upon completion of this report.

5.5 Data Adequacy Evaluation

A comparison of the data collected with the data quality objectives summarized in the SAP/QAPP (EPA 2012a,b) is presented below.

5.5.1 *Spatial and Temporal Representativeness*

The primary goal of the Comparative Exposure Investigation was to evaluate three cities outside of the Libby Valley encompassing a range of potential reference areas to provide a frame of reference for LA levels at the Libby Site (EPA 2012a). In order to provide a reasonable spatial representation at each city, three ABS locations were evaluated (nine total ABS locations). One additional ABS location at Flower Creek was added to this investigation to provide data on LA levels within the Libby Valley.

The number of ABS locations sampled met the specified goal for all ABS exposure areas, and met the target total number of locations (N=10). Inspection of the map of ABS locations for each city (see **Figure 3-1**) shows that the selected areas were representative of the compass directions surrounding each city. Based on this, data are considered spatially representative. All outdoor ABS areas were evaluated in one sampling round representative of the season where exposures are likely to be the highest (e.g., dry summer months). Data are not considered temporally representative of long-term conditions, but were intentionally biased towards likely higher exposure time periods.

5.5.2 *Sample Completeness*

Completeness is defined as the fraction of samples that were planned that were successfully collected and analyzed. In summary, the Comparative Exposure Investigation was able to collect and perform TEM analyses for all of the target number of samples identified in the SAP/QAPP (i.e., 100% completeness). The following sections provided detailed information on sample completeness for each medium.

5.5.2.1 ABS Air

As described previously, two different disturbance scenarios were evaluated at each ABS location – child digging and fireline digging. During each disturbance scenario, the individual performing the activity wore two personal air monitors (HV and LV) to collect air samples for asbestos analysis. The target number of personal air samples for the outdoor ABS program was 60 samples [(10 ABS locations x 1 digging scenario x 1 actor) + (10 ABS locations x 1 fireline scenario x 2 actors)]. All of these samples were successfully collected and either the HV or the LV filter was analyzed (i.e., 100% completeness).

5.5.2.2 Soil

Based on the SAP/QAPP, for each child digging ABS area, one 30-point soil composite sample was to be collected and prepared using FBAS for TEM analysis. Three replicate filters for each soil sample were prepared and analyzed using TEM by different laboratories. Based on this, the target number of soil TEM filters for the Comparative Exposure Investigation was 30 (10 ABS locations x 1 soil sample per location x 3 replicate filters per sample). The Comparative

Exposure Investigation was able to collect and perform TEM analyses for all of the target number of soil samples (i.e., 100% completeness).

In addition, visual inspection for vermiculite was to be performed at each of the 30 inspection points. The target number of visible inspection surveys was 300 (10 ABS locations x 30-point composite sample). Thus, completeness was also 100% for visible vermiculite inspection.

5.5.2.3 Tree Bark

Based on the SAP/QAPP, for each sampling location, one composite tree bark sample (composite of circular bark samples collected from 3 trees) was to be collected for analysis of LA by TEM. A total of 10 tree bark composite samples and one duplicate sample were collected. Three replicate filters were prepared for each sample and analyzed for total LA by TEM. The Comparative Exposure Investigation was able to collect and perform TEM analyses for all of the target number of tree bark samples (i.e., 100% completeness).

5.5.2.4 Duff

Based on the SAP/QAPP, for each sampling location, a 30–point composite sample of duff was to be collected for analysis of LA by TEM. A total of 10 duff composite samples plus one duplicate sample were collected. Three replicate filters were prepared for each sample and analyzed for total LA by TEM. The Comparative Exposure Investigation was able to collect and perform TEM analyses for all of the target number of duff samples (i.e., 100% completeness).

5.5.3 Analytical Sensitivity

5.5.3.1 ABS Air

The target analytical sensitivities specified in the SAP/QAPP for ABS air samples were 0.00022 cc^{-1} and 0.0025 cc^{-1} for the child digging and the fireline digging ABS scenarios, respectively.

As seen in **Table 4-3**, Achieved sensitivities for the child digging ABS scenario air samples ranged from 0.00020 to 0.00028 cc^{-1}. All three of the child digging ABS scenario HV samples from Helena were prepared indirectly due to filter overloading with particulates. Sensitivities for these three samples were approximately 0.00028 cc^{-1} and were slightly higher than the target sensitivity. For these three samples, the analysis stopped after examining about 1,500 grid openings (i.e., the analysis reached the maximum filter area stopping rule of 20 mm^2). All other samples met the target sensitivity.

As seen in **Table 4-3**, achieved sensitivities for the fireline digging ABS scenario air samples ranged from 0.00022 cc^{-1} to 0.0025 cc^{-1}. All of ABS fireline air sample analyses achieved the specified target sensitivity (in some cases, even better sensitivities than required were achieved).

5.5.3.2 Soil

The target analytical sensitivity specified in the SAP/QAPP for the FBAS soil samples was 6.3E+03 g^{-1}. Achieved sensitivities for total LA ranged from 1.7E+04 g^{-1} to 4.6E+05 g^{-1} (see **Appendix C**). Thus, none of the FBAS soil samples were able to achieve the target sensitivity, with most analyses stopping after examining about 300 grid openings because the maximum filter area stopping rule of 3.0 mm^2 was met.

Despite the fact that the target analytical sensitivity was not achieved, the results show that analyses of soil were able to detect LA structures, even where the analysis of asbestos in other media (ABS air, duff, tree bark) did not. Thus, the fact that the FBAS soil analyses did not achieve the target analytical sensitivity is not considered to be an important data limitation.

5.5.3.3 Tree Bark

The target analytical sensitivity specified in the SAP/QAPP for the tree bark samples was 100,000 cm^{-2}. Achieved sensitivities for the tree bark samples ranged from 2,355 cm^{-2} to 96,511 cm^{-2} (see **Appendix C**). Thus, all tree bark analyses achieved the target sensitivity (in many cases, even better sensitivities than required were achieved).

5.5.3.4 Duff

The target analytical sensitivity specified in the SAP/QAPP for the duff samples was 1E+07 g^{-1}. Achieved sensitivities for the duff samples ranged from 1E+06 g^{-1} to 9E+06 g^{-1} (see **Appendix C**). All of duff sample analyses achieved the specified target sensitivity (in some cases, even better sensitivities than required were achieved).

5.5.4 Sample Duration for ABS Air Samples

As specified in the SAP/QAPP, the child digging ABS scenario was planned to span a 2-hour time interval and the fireline digging ABS scenario was to be performed for 30 minutes. These times were selected to help ensure that samples captured a sufficiently long sampling interval that the sample would be a reliable measure of the long-term mean concentration during an ABS activity, and would not be unduly influenced by short-term (minute to minute) spikes and dips in the concentration. The actual sample duration for all ABS air samples achieved the target durations. Based on this, it is concluded that all ABS samples met the sample duration goals.

5.5.5 Preparation Method for ABS Air Samples

As noted above, three of the child digging ABS scenario HV samples were prepared indirectly (following ashing of the primary filter). Indirect preparation methods have the potential to increase structure counts, particularly for chrysotile asbestos (Hwang and Wang 1983; HEI-AR

1991; Breysse 1991). The effects of indirect preparation on amphibole asbestos are generally much smaller (Bishop *et al.* 1978; Sahle and Laszlo, 1996; Harris 2009). Libby-specific data on the affect of indirect preparation on reported air concentrations suggest that indirect preparation may increase the reported air concentration by a factor of about 2-3 (Berry *et al.* 2013). For this investigation, the affect of indirect preparation is a minor source of uncertainty since all ABS air samples were non-detect.

5.5.6 Evenness of Filter Loading

The TEM analysis only examines a portion of the total filter. For the purposes of computing the concentration in the entire sample, it is assumed that the filter is evenly loaded. The assessment of filter loading evenness is evaluated using a Chi-square (CHISQ) test, as described in ISO 10312:1995(E) Annex F2. If a filter fails the CHISQ test for evenness (i.e. i.e., p value ≥ 0.001), the reported result may not be representative of the true concentration in the sample, and the results should be given low confidence. An evaluation of filter loading for the ABS air, FBAS soil, tree bark, and duff samples from this investigation showed that, all filters passed the CHISQ test for evenness (see **Appendix C**). Thus, it is concluded that uneven filter loading is not of significant concern for any of the samples analyzed in this investigation.

5.5.7 Data Adequacy Conclusions

Based on the data adequacy assessment presented above it is concluded that the data generated during the Comparative Exposure Investigation met the DQOs stated in the governing SAP/QAPP.

5.6 Data Quality Conclusions

Taken together, these results indicate that data collected as part of the Comparative Exposure program are representative, of acceptable quality, and considered to be reliable and appropriate for use. As noted above, information regarding program-wide data quality of the preparation and analytical laboratories from 2010-2012 is currently in preparation (CB&I 2013). Interpretation of the data quality is subject to change upon completion of this report.

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TABLES

Table 3-1

Number of Samples Collected and Analyzed

Panel A: Eureka, Helena, Whitefish

Media	Number of Field Samples Collected per ABS Area	Number of Field Samples Collected per Town	Total Number of Samples Collected	Number of Analyses Performed
Bark	1	3	9 field samples; 1 field duplicate	30 (3 replicates per sample)
Duff	1	3	9 field samples; 1 field duplicate	30 (3 replicates per sample)
Soil	1	3	9 field samples; 1 field duplicate	30 (3 replicates per sample)
Digging ABS Air	2 (1 HV, 1 LV)	6 (3 HV, 3 LV)	18 (9 HV, 9 LV)	9*
Fireline ABS Air	4 (2 HV, 2 LV)	12 (6 HV, 6 LV)	36 (18 HV, 18 LV)	18*

Panel B. Flower Creek

Media	Number of Field Samples Collected	Number of Analyses Performed
Bark	1	3 (3 replicates per sample)
Duff	1	3 (3 replicates per sample)
Soil	1	3 (3 replicates per sample)
Digging ABS Air	2 (1 HV, 1 LV)	1*
Fireline ABS Air	4 (2 HV, 2 LV)	2*

* Either the HV or LV was selected for analysis, depending upon filter loading.

ABS = activity-based sampling

HV = high volume filter

LV= low volume filter

Table 4-1
Comparative Exposure Investigation: FBAS Soil Results

Location	Sample ID	Soil Total LA Concentration (s/g)				
		FBAS Filter Replicate #1	FBAS Filter Replicate #2	FBAS Filter Replicate #3	Mean by Location	Mean Across Locations
Helena Area A	CX-00001	2E+04 1 XX AC**	0E+00	0E+00	8E+03	3E+03
Helena Area B	CX-00015	0E+00 **	0E+00	0E+00	0E+00	
Helena Area C	CX-00025	0E+00	0E+00	0E+00	0E+00	
Whitefish Area A	CX-00050	0E+00 **	0E+00	0E+00	0E+00	1E+04
Whitefish Area B	CX-00062	0E+00	0E+00	0E+00	0E+00	
Whitefish Area C	CX-00037	0E+00 **	9E+04 1 XX TR	0E+00 **	3E+04	
Eureka Area A	CX-00093	0E+00	0E+00	0E+00 **	0E+00	7E+04
Eureka Area B	CX-00083	0E+00	9E+04 1 XX AC	0E+00	3E+04	
Eureka Area C	CX-00072	9E+04 1 XX AC	5E+05 1 XX AC	0E+00	2E+05	
Flower Creek	CX-00103	3E+05 6 WRTA NaK**	6E+05 6 WRTA NaK, 1 XX AC	0E+00	3E+05	3E+05
Field Duplicate						
Whitefish Area A	CX-00051	0E+00	3E+04 1 XX TR	0E+00	1E+04	---

No visible vermiculite was noted for any soil sampling point.

FBAS = fluidized bed asbestos segregator
ID = identifier
LA = Libby amphibole
s/g = structures per gram of soil

Structure-specific notes:
NaK = structure spectra contains sodium and potassium
XX = structure spectra not contain sodium or potassium
WRTA = structure is characteristic of the winchite, richterite, tremolite, actinolite solid solution series
AC = structure is characteristic of actinolite
TR = structure is characteristic of tremolite
** Pyroxene structures were observed during the analysis.

Table 4-2
Soil Moisture Results

Location	Digging ABS Areas						Fireline ABS Areas		
	ABS Area A		ABS Area B		ABS Area C		Average of Ten Moisture Readings		
	Moisture	Soil Moisture Deficiency[1]	Moisture	Soil Moisture Deficiency[1]	Moisture	Soil Moisture Deficiency[1]	ABS Area A	ABS Area B	ABS Area C
Helena	1.6%	75%-100%	2.7%	75%-100%	3.5%	75%-100%	3.5%	4.9%	1.3%
Whitefish	2.6%	75%-100%	7.6%	75%-100%	3.6%	75%-100%	NA	<0.2	1.4%
Eureka	NA	NA	3.0%	75%-100%	8.3%	75%-100%	6.0%	15.7%	3.8%
Flower Creek	5.5%	75%-100%	--		--		4.9%	--	--

-- = Only one ABS area evaluated for Flower Creek
ABS = activity-based sampling
NA = Not available
[1] Measured by hand squeeze appearance method

Table 4-3
Comparative Exposure Investigation: ABS Air Results

Location	Child Digging ABS Air				Fireline Digging ABS Air							
					ABS - Actor 1				ABS - Actor 2			
	Sample ID		Achieved Sensitivity (cc^{-1})	PCME LA Air Conc. (s/cc)	Sample ID		Achieved Sensitivity (cc^{-1})	PCME LA Air Conc. (s/cc)	Sample ID		Achieved Sensitivity (cc^{-1})	PCME LA Air Conc. (s/cc)
	High volume filter (HV)	Low volume filter (LV)			High volume filter (HV)	Low volume filter (LV)			High volume filter (HV)	Low volume filter (LV)		
Helena Area A	CX-00005	CX-00006	0.00028 IA	0.0	CX-00009	CX-00010	0.0016	0.0	CX-00011	CX-00012	0.0017	0.0
Helena Area B	CX-00014	CX-00018	0.00028 IA	0.0	CX-00021	CX-00022	0.0022	0.0	CX-00023	CX-00024	0.0022	0.0
Helena Area C	CX-00029	CX-00030	0.00028 IA	0.0	CX-00033	CX-00034	0.0023	0.0	CX-00035	CX-00036	0.0023	0.0
Whitefish Area A	CX-00055	CX-00056	0.00022	0.0	CX-00057	CX-00058	0.0025	0.0	CX-00060	CX-00061	0.0023	0.0
Whitefish Area B	CX-00066	CX-00067	0.00021	0.0	CX-00068	CX-00069	0.0021	0.0	CX-00070	CX-00071	0.0022	0.0 *
Whitefish Area C	CX-00042	CX-00043	0.00020	0.0	CX-00044	CX-00045	0.0024	0.0	CX-00047	CX-00048	0.0023	0.0
Eureka Area A	CX-00097	CX-00098	0.00022	0.0	CX-00099	CX-00100	0.0025	0.0	CX-00101	CX-00102	0.0025	0.0
Eureka Area B	CX-00087	CX-00088	0.00022	0.0	CX-00089	CX-00090	0.0025	0.0	CX-00091	CX-00092	0.0025	0.0
Eureka Area C	CX-00077	CX-00078	0.00022	0.0	CX-00079	CX-00080	0.0025	0.0 **	CX-00081	CX-00082	0.0025	0.0
Flower Creek	CX-00107	CX-00108	0.00022	0.0	CX-00109	CX-00110	0.00022	0.0 **	CX-00111	CX-00112	0.00022	0.0

ABS = activity-based sampling
cc^{-1} = per cubic centimeter of air
conc = concentration
ID = identifier
LA = Libby amphibole
PCME = phase contrast microscopy-equivalent
s/cc = structures per cubic centimeter of air

* One LA structure was observed (XX TR), but was not counted because it did not meet PCME recording rules.
** Pyroxene structures were observed during the analysis.
IA = High volume filter was prepared indirectly (with ashing) due to high particulate loading.

Table 4-4
Comparative Exposure Investigation: Tree Bark and Duff Results

Panel A: Tree Bark

Location	Sample ID	Tree Bark Total LA Surface Loading (Ms/cm^2)			
		Analysis Replicate #1	Analysis Replicate #2	Analysis Replicate #3	Mean across replicates
Helena Area A	CX-00003	0.0	0.0	0.0	0.0
Helena Area B	CX-00017	0.0	0.0	0.0	0.0
Helena Area C	CX-00027	0.0	0.0	0.0	0.0
Whitefish Area A	CX-00053	0.0	0.0	0.0	0.0
Whitefish Area B	CX-00064	0.0	0.0	0.0	0.0
Whitefish Area C	CX-00040	0.0	0.0	0.0	0.0
Eureka Area A	CX-00095	0.0	0.0	0.0	0.0
Eureka Area B	CX-00085	0.0	0.0	0.0	0.0
Eureka Area C	CX-00074	0.0	0.0	0.0	0.0
Flower Creek	CX-00105	0.0	0.06 1 WRTA NaK	0.1 2 WRTA NaK	0.06
Field Duplicate					
Eureka Area C	CX-00075	0.0	0.0	0.0	0.0

Panel B: Duff

Location	Sample ID	Duff Total LA Concentration (Ms/g, dw)			
		Analysis Replicate #1	Analysis Replicate #2	Analysis Replicate #3	Mean across replicates
Helena Area A	CX-00002	0.0	0.0	0.0	0.0
Helena Area B	CX-00016	0.0	0.0	0.0	0.0
Helena Area C	CX-00026	0.0	0.0	0.0	0.0
Whitefish Area A	CX-00052	0.0	0.0	0.0	0.0
Whitefish Area B	CX-00063	0.0	0.0	0.0	0.0
Whitefish Area C	CX-00038	0.0	0.0	0.0	0.0
Eureka Area A	CX-00094	0.0	0.0	0.0	0.0
Eureka Area B	CX-00084	0.0	0.0	0.0	0.0
Eureka Area C	CX-00073	0.0	0.0	0.0	0.0
Flower Creek	CX-00104	0.0	0.0	8.2 1 WRTA NaK	2.7
Field Duplicate					
Whitefish Area C	CX-00039	0.0	0.0	0.0	0.0

ID = identifier
LA = Libby amphibole
Ms/cm^2 = million LA structures per square centimeter of bark surface area
Ms/g, dw = million LA structures per gram of duff material based on dry weight

Structure-specific notes:
NaK = structure spectra contains sodium and potassium
WRTA = structure is characteristic of the winchite, richterite, tremolite, actinolite solid solution series

Table 5-1
Impact Assessment for Field Modification LFO-000168

Date	Description of Modification	Implications of Modification	Data Quality Indicator
8/7/12 – 8/22/12	Field Team Leader for all field sampling activities will be Asami Tanimoto.	There are no anticipated negative implications of this modification.	No Bias
8/7/12 – 8/13/12	Due to lack of functioning low volume SKC pumps, health and safety samples could not be collected during the first 3 events for the Fireline Digging ABS. They were collected during the 4th and 5th events (Whitefish C and A).	There are no anticipated negative implications of this modification.	No Bias
8/9/2012	All available low volume SKC pumps malfunctioned and were not available for the events specified above. "Low volume" samples were collected using F&J DF-40L-8 pump at approximately 2.0 L/min for Child Digging ABS and F&J L-15P pump at just under 5.0 L/min for Fireline Digging ABS. OSHA samples for Child Digging were collected using F&J DF-40L-8 pumps at approximately 2.0 L/min.	There are no anticipated negative implications of this modification for the Child's Play activity. The low volume sample for Fire Line may be overloaded because of the higher volume. High volume samples may be analyzed for either scenario.	No Bias
8/13/12 – 8/15/12	Some F&J L-15P pumps could not reach 5.5 L/min at higher elevations. The following high volume pumps were calibrated to less than 5.5 L/min: - Whitefish Area A – Fireline Digging ABS Actor 2 - Whitefish Area B – Both Fireline Digging ABS actors - Eureka Area C – Fireline Digging ABS Actor 1	There are no anticipated negative implications of this modification.	No Bias
8/7/12 – 8/13/12, 8/15/12	Pine trees were sample for tree bark at the following locations as they were more prevalent in the area.	These trees had rough bark and therefore there are no anticipated negative implications of this modification.	No Bias
8/7/12 – 8/22/12	ABS Property Background Form was not used to record soil moisture as the form has been developed in the past to record information on residential properties. Soil moisture readings were recorded in the logbook.	There are no anticipated negative implications of this modification.	No Bias
8/7/12 – 8/22/12	Two boxes of air cassette lot number 25518 were set aside from project supply by Nic Pisciotta (CDM Smith). Lot blank for these air cassettes were previously analyzed and results verified.	There are no anticipated negative implications of this modification.	No Bias
8/7/12 – 8/22/12	No equipment rinsate was collected as new hole saw and chisel were used at each sample location.There are no anticipated negative implications of this modification. A duplicate 3-point composite tree bark sample was collected as a QC sample.	There are no anticipated negative implications of this modification.	No Bias
8/14/2012	Whitefish B location was changed. The original location was on a single lane unpaved road with steep terrain on both sides and posed safety concern for the ABS team. The original area was also mostly a burn area and therefore, there were no suitable trees for tree bark sampling. The new location, verbally approved by Liz Fagen (EPA RPM for OU4) on 8/13/12, was near the intersection of Forest Road 9848 and 316, between the road and the creek. See Figure 3-1 for location.	There are no anticipated negative implications of this modification	No Bias

TABLE 5-2
COMPARISON OF ORIGINAL AND FIELD DUPLICATE RESULTS FOR SOIL

Sample Type	Sample ID	FBAS Filter Replicate 1		FBAS Filter Replicate 2		FBAS Filter Replicate 3		Pooled Across Replicates		Poisson Ratio Comparison (based on 90% confidence interval)
		No. of LA structures observed	Achieved Sensitivity (g^{-1})	No. of LA structures observed	Achieved Sensitivity (g^{-1})	No. of LA structures observed	Achieved Sensitivity (g^{-1})	No. of LA structures observed	Achieved Sensitivity (g^{-1})	
Original	CX-00050	0	4.69E+04	0	9.41E+04	0	4.43E+04	0	1.83E+04	[0-45.75] The rates are not different
Duplicate	CX-00051	0	2.35E+04	1	3.11E+04	0	1.77E+04	1	7.62E+03	

FBAS = fluidized bed asbestos segregator
g^{-1} = per gram of soil
ID = identifier
LA = Libby amphibole
No. = number

Note: Field duplicate evaluation not shown for tree bark or duff because all replicates were non-detect.

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FIGURES

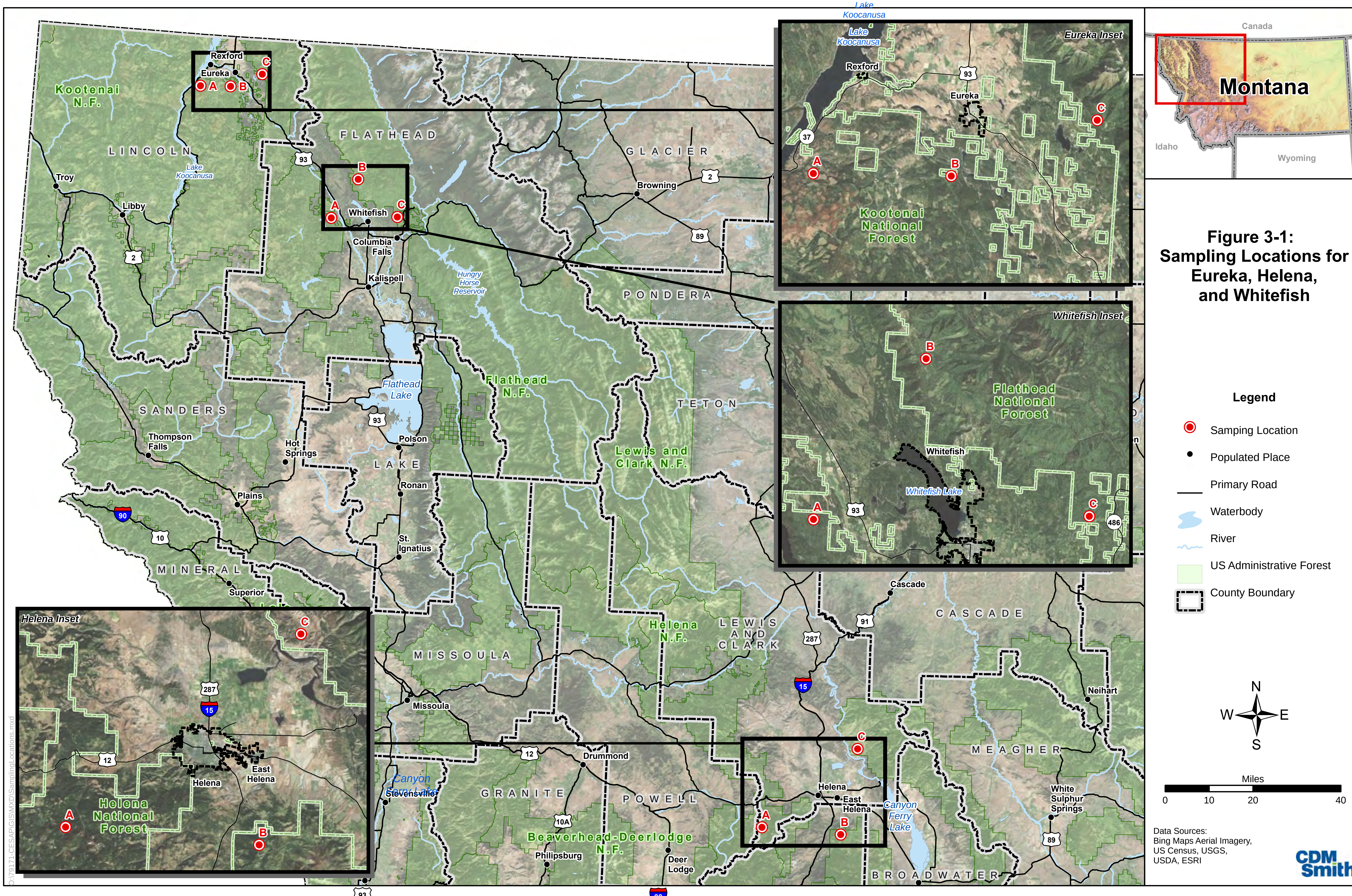
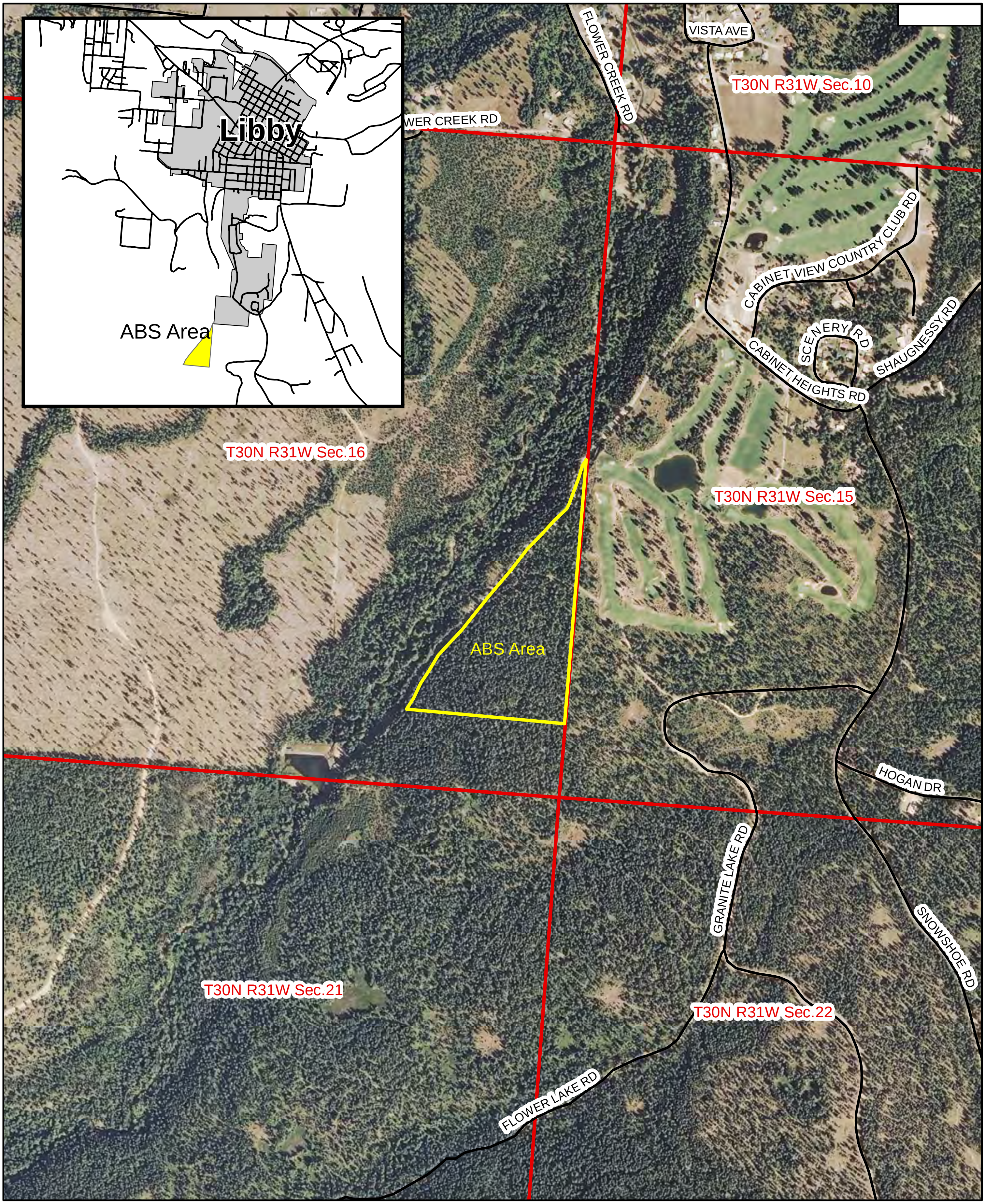


Figure 3-1:
Sampling Locations for Eureka, Helena, and Whitefish



Imagery Source: NAIP 2011
Public Land Survey: BLM (1:100,000)

This map is for general reference only and is not to be used to establish legal boundaries or for any other legal purpose. Road and PLS data is from public sources and subject to inherent inaccuracies.

CDM Smith

N

1:12,000

1 inch = 1,000 feet

1,300 650 0 1,300 Feet

Figure 3-2 Flower Creek Sampling Location

FIGURE 3-3

PHOTO OF TREE AFTER BARK SAMPLE COLLECTION

FIGURE 3-4

PHOTO OF ABS CHILD DIGGING SCENARIO

FIGURE 3-5

PHOTO OF ABS FIRELINE DIGGING SCENARIO

Data Summary Report: Comparative Exposure Study
Libby Asbestos Superfund Site, Operable Unit 4

APPENDICES

[provided electronically]